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Camel Systems and Pastoralists' Lifestyle in Semi-Deserts and Mountains: Constraints and Challenges

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Abstract

Camels are vital to the daily life of all desert dwellers, especially Bedouins, for whom they form a source of food, a means of transportation and recreation. To appreciate the unique contribution that Arabian camels make towards the community life and the history of the desert lands, in this paper, the pastoral production systems observed across three major regions - Butana, Kordofan and Darfur - are discussed. The field survey based study was conducted from August 2011 to May 2014 using structured interview method to determine the limitations and challenges faced by camel pastoral community in main camel production regions of Sudan. The results revealed that the average of calving interval was 30 months; male camel is rutting for 3 months during rainy season. She-camel gives birth to 6-8 calves throughout the life. The average milk yield was 3 liters per day with the lactation period extended to more than 10 months. The calf is weaned for 10 months or more. Social prestige and continuity of traditional heritage are the major reasons for keeping animals rather than economic revenue. However, it was found that the security issues are limiting camel breeding practices and pastoralists' movement in the semi-desert and mountain regions. Internal conflicts between farmers and pastoralists that often develop into tribal wars also affected pastoral production systems. Such constraints in addition to the lack of government support and favorable policies present major challenges to camel pastoral system in the region.

Keywords

Challenges; Camel; Mountain; Pastoralist; Pastoralism; Sudan

1. Introduction

The camel is an important species uniquely adapted to hot and arid environments (Schwartz, 1992) and contributes significantly to the food security of nomadic pastoral households. This unique adaptability makes this species ideal for human use in the arid

and semi-arid land conditions. The contributions of camels to the human welfare in the developing countries are generally obscured by several factors, which tend to underestimate their true value. Firstly, the estimates of camel populations are usually inaccurate due to the lack of a periodical census. Secondly, their products seldom enter a formal marketing system; thus, their contribution to subsistence and the national economy is rarely realized (Njiru, 1993).

Ahmed & Iqbal (2012) stated that the productivity of the animal depends on genetics, health status, and management. Proper management and health practices ultimately lead to improved production and reproduction. The existing traditional management practices of camel production require interventions for the improvement of camel productivity. Increasing human population pressure and declining per capita production of food in Africa precipitated an urgent need to develop previously marginal resources, such as the semi-arid and arid rangelands, and to optimize their utilization through appropriate livestock production systems among which camel production is certainly the most suitable (Schwartz, 1992). Despite the camel's considerable contribution to food security in semi-dry and dry zones, and existence as a major component of the agro-pastoral systems in vast pastoral areas in Africa and Asia, little is known about its production potential and production systems compared to other domestic animals. Most of the previous research conducted on camels stresses on diseases, reproductive physiology, and characterization (Mohammed, 2000). The available information on camel production potential and production systems, especially in Sudan, remains inadequate. Pastoral camel production is under pressure because of multiple changes in the production environment. Increasing human population pressure on pastoral grazing areas and the economic implications resulting from diseases and lack of veterinary services are some of the factors that adversely affect traditional camel production. Additionally, reproductive performance is low in camels due to late first parturition, long parturition intervals, and high calf mortality. Improvement in reproductive performance and reduction of animal losses by management measures that apply to a mobile system, appear to offer possibilities of increasing camel productivity and capacity to support the increasing human population. An adequate understanding of traditional camel production practices forms the foundation on which improvements and innovations could be based (Farah et al., 2004). In line with this objective, current study was carried out in three main regions of camel production in Sudan. The main aim is to clarify the camel management systems, husbandry practices, and cameleer's constraints and challenges. Additionally, we also identify the socio-economic values of camel, and contribution of camel products to the improvement of overall household incomes.

2. Methodology

2.1 Study Areas

The study was conducted in major camel production regions of Sudan, which comprise Butana, Kordofan, and Darfur.Description of the regions is as follows.

The Butana region

Butana lies in the Sahel zone of Sudan, surrounded with mountains in the east, center, and south. It is bounded by the river Nile and Blue Nile from the west, River Atbara from north and Geddarif railways on the eastern and southern boundaries (Map 1). It covers an area of approximately 12,000 square kilometers (Abusin, 1990). The Butana is located at the cusp of climatic and ecological transition zone that has Savannah in the south and Sahara in the north. Based on the long-term average precipitation, Sahel is marked by annual precipitation of up to 100 mm in the North and 600 in the South. Duration of the rain varies from 2 to 5 months (June to

September/October). The extreme spatial and temporal variability of rainfall resulting from the inter-annual fluctuations in the north-ward drift of the Inter-Tropical Convergence Zone (ITCZ) leads to unpredictability in the rainy season, and thus, to the recurring drought events at an irregular interval.

According to Al-Khouri & Majid (2000), inter-annual variability of the rainfall with the severe drought events leads to a natural shift in the vegetation pattern across several hundred kilometers. The temperature in the Butana is generally considered high all-round the year, with a drop in July and August as a result of moisture and cloudiness. It rises again by September, and then drops to a minimum with the advance of cool Northern winds during November. Highest temperature is recorded in April, while January remains the coldest month (Abusin, 1990).

There are three main types of natural vegetation found across Butana. *Acacia* trees form the major perennial vegetation, including *Acacia terlilus*, *Acacia seyal,* and *Acacia mellifera*. The shrubs are the second perennial vegetation found in Butana and it includes bushy grasses scattered all over the region. The third type includes the annual grasses and herbs. These herbaceous plants are dominant during the wet season and only a few species sustain during the dry season. During the rainy season, the low areas that remain covered in water for a long time become less vegetated due to the spoilage of seeds. The variation in the rainfall in addition to the variations in relief, drainage, and parent material produce a clear local difference in the Butana soil.

The Kordofan region

Kordofan region is located in an arid and semi-desert ecological zone that is surrounded by the mountains both in the north and south. It is located between 12°: 25`- 13°: 45`N and longitudes 24°:45`- 30°:30` E. The rainy season in this zone is shorter and only extends from July to October with August being the wettest month. The average annual rainfall estimated in this region was 298 mm with uniform relative humidity ranging between 22-25% in the dry season and 75% during the rainy season. Wind velocity is usually less than 8 km/hour. The vegetation cover which is a reflection of that climatic zone and soil type range from a sparse growth of drought-resistant grasses and dwarf scrub in the north through a belt of open wood and grass in semi–arid central region to open forest in the well-watered south. The common trees belong to the species of genus *Acacia*. Whereas, the vegetation covers includes grasses, herbs, shrubs, and small trees. Livestock and its product form the primary source of income for over 60% of the population in this region. A traditional system of cropping in combination with animal husbandry predominates the state (MARF, 2007). Total animal units in the state are estimated at 6 million. The animals raised mainly include sheep, goats, cattle and camel. In the northern part of the state, land use is characterized by a mobile pastoral system practiced by different nomadic tribes where each tribe has its predefined territory. In the southern part of the state, land use is characterized by a sedentary agro-pastoralist system. There are three main types of soil are widely distributed in Kordofan state: sandy soil in the northern, clay soil in the southern part, and Guarded soil distributed all over the state as stated by MOARF (2004).

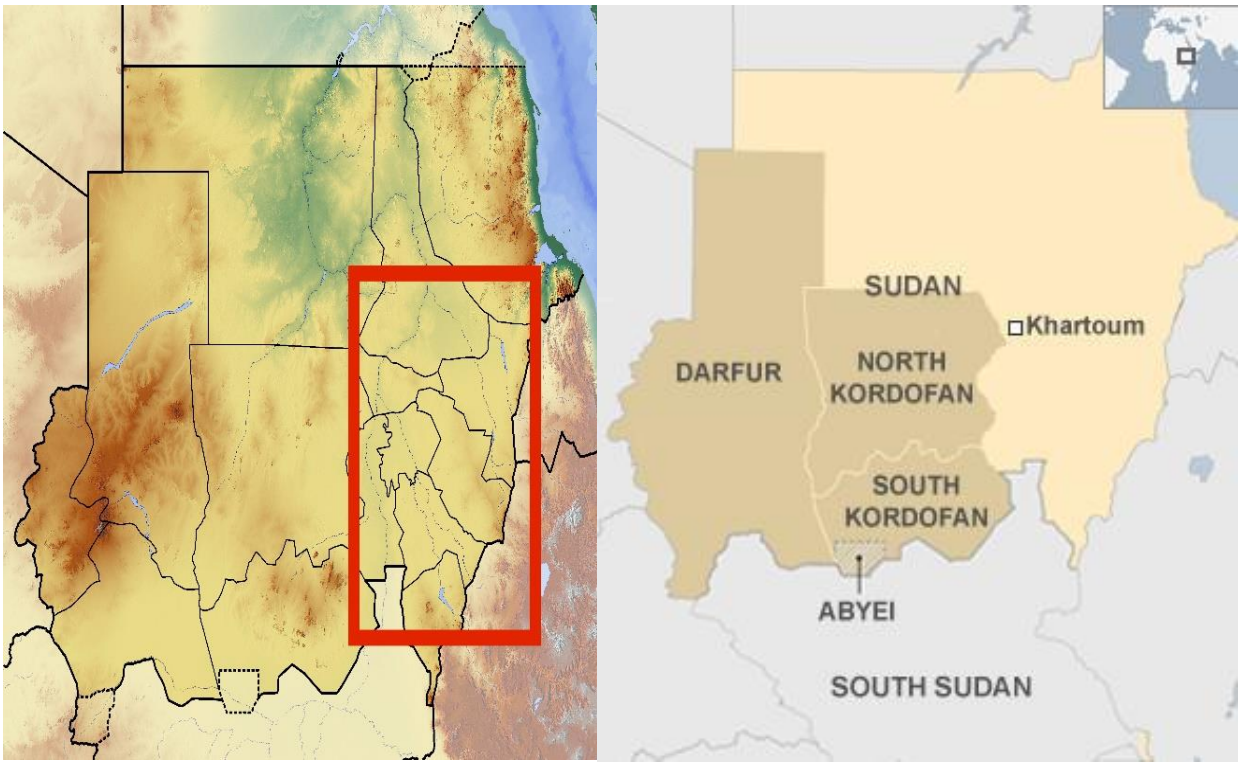
Darfur region

Darfur is a hilly area that has rich natural resource base with fertile land suitable for grazing pasture, forest, and water sources. Relatively better rainfall and existing seasonal rivers make the region fertile and less prone to droughts (Abusin, 1990). The samples were collected from the area in the Darfur region, which lies between latitude 14.45º – 11º N and longitude 22º - 24º E. Topographically, Darfur has basement rocks and is covered with a thin layer of sandy soil. Basement rock is too infertile to be farmed but provides sporadic forest cover that can be grazed by animals. Another feature of Darfur is the Marrah Mountains i.e. the volcanic plugs

created by a massif that rise up to a peak at Deriba crater where there is a small area observing temperate climate, high rainfall, and permanent springs of water (MOARF, 2004). The vegetation covering the rangeland includes grasses, shrubs, and trees (Map 2).

2.2 Survey Protocol

Data was collected through a survey that helped in identifying camel pastoralists and their views regarding the aspects including herd composition, milk production, calving management, restriction methods of calving suckling, milking times and methods, socio-economic value of camel, production and reproduction limitations, breed ecotypes, and breeding in dromedary camels under traditional management systems and nutritional evaluation of natural pasture across all the study sites. The survey was carried out using different methods as described below.



Map 1: Darfur and Kordofan regions

Questionnaire and data collection

Data was collected from 170 camel pastoralists[1], camel herders[2], and camel owners[3] in the Butana, Kordofan, and Darfur regions using structured questionnaire. The questionnaire was prepared to inquire about various aspects of camel management systems, and related constraints faced by the pastoralists. A detailed structured questionnaire was used to collect information from camel herders and owners in different regions. Simultaneously, interviews were also conducted during the field visits (Table1). The questionnaire was pre-tested to check the clarity and appropriateness of the questions.

[1] Camel pastoralist: The pastoralist is the person who rear camel herd against monthly wage from owner of the herd.
[2] Camel herder: The herder is the person who owns a herd of camels and rearing of them himself.
[3] Camel owner: The owner is the person who owns a herd of camels and does not rear himself, but hires someone to rearing it.

Direct communication and field visits

Some of the information collected during interviews was supported by field visits and meeting with chairmen of pastoralists unions in study areas. All visits and communications were carried out during the wet and dry seasons from August 2011 to May 2014.

Table 1: The regions selected for the survey of the camel management system

Region	*Number of Interviewees*
Butana	50
Kordofan	60
Darfur	60
Total	170

In addition, the samples of straws and stoves from residues of agricultural rain-fed production crops were also collected to identify their applicability in satisfying the nutritional requirements of camels and their feasibility in formulating desirable feed concentrates.

Data analysis

The professional version of Statistics 10 analytical software was used to develop comparison between the three study areas. Results are represented mainly in the form of descriptive statistical summaries.

3. Results

3.1 General Information

All the pastoralists interviewed were males. The majority of respondents (76%) were illiterate followed by those who completed primary school (21%), followed by those who completed secondary school (2.5%). There were fewer university graduates (0.5%) (Table 2).

Table 2: General information about interviewers

Regions	*N*	*Level of Education (%)*				*Interviewees (%)*		
		Illiterate	*Primary*	*Secondary*	*Graduates*	*Owner*	*herder*	*Owner herder*
Butana	50	68	22	8	2	26	40	34
Kordofan	60	78	22	0	0	1	23	76
Darfur	60	80	20	0	0	28	27	45
Total	170	76	21	2.5	0.5	21	29	50

The majority of respondents were both owner and herders of the camels, followed by those who only owned a camel and then who is working as a herder of camel (Table 2). Most of the camel herders and owners (56%) were of young age ranging between 25 and 45 years, followed by below 25 years old (22%) and above 45 years old (22%). Whereas, the majority of camel herders and owners were 83% married, but fewer (14%) were single and divorced (3%) (Table 3).

Table 3: Age and marital status of interviewers

Regions	*N*	*Age (%)*			*Martial status of interviewees (%)*		
		< 25years	*25-45 years*	*> 45 years*	*Single*	*married*	*divorced*
Butana	50	18	66	16	12	88	0
Kordofan	60	32	47	21	8	87	5
Darfur	60	16	57	27	23	73	4
Overall	170	22	56	22	14	83	3

3.2 Herd Composition and Structure

The result revealed that the size of the camel herd varies from region to region. The wide proportion of participants in Butana (60%) and Darfur (47%) held bigger herd size (more than 50 heads) compared to Kordofan region, while majority of participants in Kordofan had middle herd size (20-50 heads) compared to other regions. Generally, majority of participants (49%) had biggest herd size exceeding 50 heads of camel. Whereas, Arabi camel breed are most dominant camel herds (66%) in Sudan followed by Anafi and Bushari breed. The result of the survey (Table 4) reflects that Arabi camel breed is highly preferable breed in main camel production regions of Sudan.

Table 4: The herd size

Regions	*N*	*Herd size (%)*			*Camel breeds (%)*			
		< 20heads	*20-50 heads*	*>50 heads*	*Anafi*	*Bishri*	*Arabi*	*others*
Butana	50	0	40	60	12	12	76	0
Kordofan	60	13	47	40	8	17	75	0
Darfur	60	18	35	47	35	15	47	3
Total	170	10	41	49	18	15	66	1

In this survey, it was recorded that female camel formed a higher percentage (46%) in the herd. Clearly, the female camel acquired highest proportion (58%) of the herd in the Butana region compared to Kordofan and Darfur. Whereas the number of male camels recorded the highest percentage (55%) of the herd in Kordofan region followed by Darfur region (45%), and very few males camels were present in the herds of Butana region. It was only one male camel in the herd as shown in table 5.

Table 5: The percentage of matured male and she-camel in the herd

Regions	*N*	*No. of females (%)*			*No. of males (%)*		
		< 15 heads	*15-40 heads*	*> 40 heads*	*1*	*2-3*	*>3*
Butana	50	0	42	58	54	40	6
Kordofan	60	20	40	40	15	30	55
Darfur	60	23	37	40	18	37	45
Total	170	14	40	46	28	35	37

The majority of respondents (70%) from Darfur region have seen an increase in the camel population. In contrast, the highest percentage of respondents (52%) from the Butana region said that camel population has decreased. Generally, the results of this study reveal the increasing trend in camel population (Table 6). The preferable color of camel was asked; and respondents indicated that red camel is the most preferable among majority (50%) of respondents in the three regions followed by dark brown camel (18%), yellow camel (17%) and white camel (12%), which is least preferred by the herders in three regions. The yellow camel is also rarely preferred in the Butana region.

Table 6: The status of the camel population and preferred color

Regions	*N*	*Status of camel population (%)*			*Preferred color (%)*				
		Increasing	*Decreasing*	*Fixed*	*Black*	*Dark brown*	*Yellow*	*Red*	*White*
Butana	50	20	52	28	8	10	0	64	18
Kordofan	60	55	28	17	0	8	28	47	17
Darfur	60	70	17	13	0	35	18	44	3
Total	170	50	31	19	3	18	17	50	12

3.3 Camel Husbandry Practices

The findings of the study revealed that (80%) of the camel herders prefer grazing in natural pastures (Table 7). The majority of the pastoralists (56%) provide camels with fodder from crop residues in specially rainfed agricultural areas of Butana

region. Generally, the result revealed that the majority of participants (58%) depend on water sources from the annual river in rainy season. Majority of the herders (42%) in Butana depend on the river water and there is no irrigation canal available in Kordofan and Darfur region.

Table 7: Feeding and watering system of camel

Regions	*N*	*Feeding of camel (%)*			*Watering of camel (%)*				
		Pasture	*fodder*	*Pasture & fodder*	*River*	*Annual river*	*Half year river*	*Irrigation canal*	*Groun-dwater*
Butana	50	36	8	56	42	4	16	32	4
Kordofan	60	26	18	33	18	20	12	0	2
Darfur	60	46	18	3	0	36	23	0	1
Total	170	80	26	64	40	58	43	16	5

The majority of camel herders and owners (45%) were found to be adapted to the semi-nomadic management system in all regions (Table 8). 70% of the respondents were engaged in nomadic camel rearing system in Darfur followed by Kordofan and the low percentages (14%) were observed in Butana. Additionally, data also suggest that the majority of camel owners and herders (91%) do not prefer crossbreeding within their herd (Table 8).

Table 8: The camel breeding systems

Region	*N*	*Management system (%)*				*NBH cross-breeding (%)*	
		Transhumant	*Nomadic*	*Semi-nomadic*	*Sedentary*	*yes*	*No.*
Butana	50	0	14	66	20	18	82
Kordofan	60	0	42	48	10	7	93
Darfur	60	0	70	23	7	5	95
Total	170	0	43	45	12	9	91

This survey indicates that 55% of the camel owners do not have a clear purpose for rearing camels. It is only because they have inherited the herd from their parents they continue their traditional occupation (Table 9). However, for 33% of the respondents, camel rearing was economically profitable from trade point of view. For only 8% of them, camels were integral part of household food security and livelihood.

Table 9: The purposes of camel breeding in the traditional system (%)

Regions	*N*	*Inherited*	*Livelihood*	*Profit and export*	*Social*
Butana	50	60	8	28	4
Kordofan	60	58	5	35	2
Darfur	60	48	12	33	7
Total	170	55	8	32	5

3.4 Camel Production and Reproduction Traits

The results of the current study revealed that the majority (75%) of the female camels attain puberty at the age of 4-5 years (Table 10). The data revealed that majority of participants (60%) confirmed that a high sexual ability of Sudanese male camels; the male camel can mate more than 8 females during rutting season. Highest percentage (65%) of male camel sexual ability was recorded in Darfur region followed Butana region.

Evidently, majority of the participants (80%) confirmed 1-5% of abortions happening among their camels in base year in the Butana region. In general, wide proportion of

participants (62%) had statedthat 1-5% of abortions occurr annually in all regions (Table 11).

Table 10: The puberty age of female camel and the ability of male

Region	*N*	*Puberty age (%)*			*No. of female camel mated by male camel (%) in a rutting season*		
		<4 yrs	*4-5 yrs*	*>5 yrs*	*3-5*	*6-8*	*>8*
Butana	50	8	86	6	16	26	58
Kordofan	60	28	62	10	0	25	35
Darfur	60	13	80	7	17	18	65
Total	170	17	75	8	11	29	60

Table 11: The percentage of abortion among camel herds per year

Regions	*N*	*0 %*	*1 – 5%*	*> 5%*
Butana	50	4	80	16
Kordofan	60	30	53	17
Darfur	60	33	55	12
Total	170	23	62	15

During the period of this study, the majority of camel herders (57%) began milking the female camels on the third day of calving, especially in Kordofan (77%). 40% herders started milking on the first day immediately (Table 12). The result of the survey indicates that a high percentage of camel (89%) lactate for more than 9 months in all the study regions.

Table 12: The start of milking and the length of the lactation period

Regions	*N*	*Start of milking after calving (%)*			*Long lactation period (%)*	
		1st day	*2nd day*	*3rd day*	*6-9 month*	*>9 month*
Butana	50	40	36	24	14	86
Kordofan	60	11	12	77	5	95
Darfur	60	22	17	61	15	85
Total	170	23	20	57	11	89

The data shown in table 13 reflects that the majority of female camels (53%) produced 8-10 calves during the productive life in the pastoral system prevalent in all regions.

Table 13: The number of calving during the reproductive age of she-camel (%)

Regions	N	5-7 calves	8 – 10 calves	>10 calves
Butana	50	36	40	24
Kordofan	60	25	58	17
Darfur	60	13	60	27
Total	170	24	53	23

The results show a high percentage (46%) of camels produce a milk yield of less than 3 liters per day in all regions. In the Kordofan region, it was recorded that around 57% camels produced milk of 3-6 liters/day/head (Table 14). Many factors including type of breed, season, availability of feeds, and water sources were found to be affecting the milk yields

Table (15) shows the majority of calves (84%) were weaned off within 10 months postpartum in all regions. However, calves in the pastoral system were allowed a direct contact during the daylight with the dam even up to 2 years.

Table 14: The camel milk yield in free range (%)

Region	*N*	*<3 litres*	*3 - 6 litres*	*> 6 litres*
Butana	50	60	28	12
Kordofan	60	36	57	7
Darfur	60	45	38	17
Total	170	46	42	12

Table 15: The percentage of calf age at weaning

Regions	*N*	*6-7 months*	*8 – 10 months*	*>10 months*
Butana	50	0	16	84
Kordofan	60	0	9	91
Darfur	60	11	12	77
Total	170	4	12	84

The camel herders practiced traditional methods for calve weaning and restricted suckling throughout the day such as *Sawrar, Shomal, Hasaka*, as shown in table 16. The majority (50%) of camel herders practiced *Sawrar* method, followed by *Shomal* method, and little number of herders used *Hasaka* method. Very few herders just used pen to restrict calves from suckling. The *Sawrar* method is considered the main method for calve weaning in Kordofan region.

Table 16: The traditional methods of calf weaning and restricted suckling (%)

Regions	*N*	*Sawrar*[4]	*Shomal*[5]	*Hasaka*[6]	*Restricted to pens*
Butana	50	46	48	2	4
Kordofan	60	73	5	21	1
Darfur	60	30	23	5	42
Total	170	50	23	10	17

In the table 17, the results revealed that the majority (81%) of camel herders are allowing calf to suckling their dam before the beginning of the milking procedure. This method is traditional adopted in all camel regions. On the other hand, the highest percentage of participants (68%) said that lactating she-camel can be milked twice a day. This method is practiced more in Kordofan than in Darfur. Whereas camel herders in Butana milk a she-camel three times a day.

Table 17: The methods of milk letdown and milking times (%)

Regions	*N*	*Suckling of calf*	*Without calf*	*Both methods*	*1 time*	*Twice*	*3 times*
Butana	50	80	12	8	0	56	44
Kordofan	60	93	6	1	0	68	32
Darfur	60	71	20	9	28	58	16
Total	170	81	13	6	10	61	29

The highest percentage (58%) of respondents confirmed that the rutting season of a male camel is about 2-3 months in Kordofan (Table 18). While, almost 56% of camel herders in Butana, believed that the length of the rutting season of a male camel is more than 3 months. It was found that the majority of male camels were rutting in the rainy season rather than the winter across all the study regions.

[4] *Sawrar*: Traditional method use to cover udder teats by camel feces to restrict suckling by calve.
[5] *Shomal*: Traditional method where udder teats are covered by a piece of cloth or plastic bag to prevent calve suckling.
[6] *Hasaka*: Traditional method where a chunk ofwood is put in the calve's mouth to restrict it from suckling the dam.

Table 18: The percentage of rutting season length and season of rutting

Regions	*N*	*Long of rutting season*			*The main season of rutting*	
		<2 months	*2-3 months*	*> 3 months*	*Rainy*	*Winter*
Butana	50	4	40	56	68	32
Kordofan	60	16	58	26	88	12
Darfur	60	36	33	30	71	28
Total	170	20	44	36	76	24

Generally, majority of the respondents (55%) confirmed that the calving interval of she-camels ranged from 20-30 months postpartum (Table 19). On the other hand, majority of Darfur camel herders confirmed that the period between calving ranged from 15 to 20 months.

Table 19: The percentages of calving interval in the pastoral system

Regions	*N*	*<15 months*	*15-20 months*	*20-30 months*	*>30 months*
Butana	50	0	14	64	22
Kordofan	60	0	30	62	8
Darfur	60	0	46	42	12
Total	170	0	31	55	14

The majority of the respondents from Butana (74%) and Kordofan (41%) said that the main sign of the estrus cycle is the swelling of the vulva (Table 20). In contrast, the highest percentage of camel herders confirmed that the main sign of estrus cycle is seeking male in Darfur. On the other hand, the highest percentage of herders (93%) believed that the raising of tails is the main sign of pregnancy among the camels in Kordofan, followed by Butana and Darfur region. Moreover, the highest percentage (53%) of camel pastoralists have seen a swelling of the udder is the main sign of parturition in Kordofan followed Butana region.

Table 20: The reproduction signs among the camels identifiedby the herders (%)

Reproduction signs	*Butana*	*Kordofan*	*Darfur*	*Total*
Sign of estrus cycle:				
Frequent urination	12	6	20	13
Swelling of vulva	74	41	13	45
Seeking male	14	53	67	42
Sign of parturition:				
Isolation	6	33	22	20
Swelling of udder	44	53	7	35
Restlessness	36	9	53	33
Swelling of vulva	14	5	18	12
Detection of pregnancy				
Raise-up tail and coil	90	93	90	91
Refuse male	10	7	10	9

In the table 21, the result of the survey revealed that the highest percentage of herders (44%) in Butana mentioned more than 5% of the calving mortality ratio in their herds. The highest percentage of herders (73%) reported the ratio of mortality ranged from 1 to 5% in the herd in Kordofan.

The majority of camel herders mentioned the main constraints of camel production as shown in table 22. The highest percentage of herders (78%) reported the shortage

of pasture and feeding as the main problem in Butana followed by Kordofan. Similarly, the highest percentage of camel herders (50%) mentioned lack of security as the most pressing challenge for camel production in Kordofan than in Darfur.

Table 21: The percentage of calve mortality per year

Regions	*N*	*Zero*	*1-5%*	*>5%*
Butana	50	0	56	44
Kordofan	60	18	73	9
Darfur	60	52	36	12
Total	170	24	55	21

Table 22: The problems facing the rearing of camels in the pastoral system

Problems	*Butana (%)*	*Kordofan (%)*	*Darfur (%)*	*Total (%)*
Lack of veterinary services	12	5	36	18
Shortage of pasture and feeding	78	23	12	35
Shortage of water	4	18	4	9
Lack of security	0	50	43	33
Taxes	6	4	5	5

4. Discussion

Herd composition and structure

Camels play an important role in the local economy of the pastoral community and are central to the survival of pastoralists in the desert, and semi-desert regions in Sudan. The current survey emphasizes on the camel rearing practices in three main regions of Sudan.

It was found that the average herd size in the region is around 50 heads. This finding is in tune with Bakhiet's (2008) findings, who reported that the average camel herd size in Sudan is 75.3 heads. Also, it was mentioned that female camels constitute around 74% of the total herd size. The insights gathered from the camel herders explain that the size of camel herds largely depend on the availability of water and food and high veterinary care rather than the changing lifestyle of pastoralists. The majority of camels in Sudan belong to the pack type (Arabi and Rashaidi camels); the Arabi camel has a wide geographic distribution in Sudan because it produces high quality meat and milk. Finding of the present study agrees with a study stating that the camel breeds in Sudan, which produced high quality of meat, are highly integrated into the regional market (Al-Khouri & Majid, 2000).

The result of the current survey highlights a decline in the camel population. This finding contradicts the finding of Faye et al. (2011), who stated that the camel population growth in Sudan is higher than the world growth i.e., 2% per year on an average. However, this growth is not regular. Observations from three time periods substantiate this claim. It was observed that from 1961 to 1978, a medium growth (1.3%) was recorded, from 1979 to 2000 a low growth (0.95) was recorded, and from 2001 onwards a rapid growth of 5.14% per year was recorded. These differences could be attributed to the impact of drought and flaws in the livestock census data. Additionally, the factors like lack of security, prevalence of diseases, shortage of pasture, and illegal export of female camel also impact the camel population and its growth in Sudan.

In Nigeria, the majority of the camel pastoralists prefer camel of dark brown phenotype breed (Abdelrahman et al., 2011). The result of the current study coincides with the finding of Abdelrahman et al. (2011). The preference of camel differs according to the difference of participants' visions. They believed that good camel traits are the productivity of milk and meat. Other traits were considered insignificant. Generally, the dark brown camel is preferred by some herders, while red camel is preferable by almost all herders in camel production regions of Sudan.

Management and husbandry practices

In the current study, most of the camel herders were depended on natural rangelands for grazing their herds. The findings of current study are similar to those reported by Idriss (2003). Bakheit et al. (2008) mentioned that the decrease in available range land and pastures is a result of agricultural activities on natural pasture. As a result, most of the income of camel owners goes in purchasing crop residues in the Butana region. Whereas the camel owners in Kordofan solve the shortage of feed and water supply by adopting long migration routes towards the south.

The nomadic and semi-nomadic systems are well adopted systems for camel production in Sudan. The finding of current study agrees with Al-Khouri & Majid (2000) study. They reported that three camel production systems were mainly found in Sudan: Nomadic, transhumant, and sedentary system. No description for the transhumant system was mentioned in the current study as the transhumant camel herders remained unapproachable because of their long-term migrations. It was also found that crossbreeding of camels is not appreciated among all herders in the study regions as it helps them to maintain their camel traits and avoid undesirable traits. In the long run such management style can lead to a decline in positive production traits among the camels unless awareness about the benefits of crossbreeding are introduced.

The majority of participants had inherited their camel population from their parents and they were not looking forward to develop their system to be more profitable and economically dependable. The findings of this study agree with Bakheit et al. (2008) who mentioned about the low cost of keeping a camel. As camels are drought-tolerant animals, they are able to survive in adverse conditions compared to other livestock. This also remains one of the primary reasons for the people to rear camels.

Camel production and reproduction traits

Almost the age of female camels at first gestation ranges 4 to 5 years. This is similar to the finding of Abdelrahman et al. (2011), who stated that camel bull and heifer mean ages at first mating were 5.63 and 3.85 years, respectively. The maturity age of a female camel may depend upon many factors such as nutrition status, breed, ecotype, health condition, and husbandry practices. According to Wilson (1989), sexual maturity in camels may be correlated not only with absolute age and condition but also with other factors affecting the onset of the breeding season such as nutrition and climate. In addition, he reported that the mean ratio of camel cows to a camel bulls during the mating season was 47.8 cows per bull. A high percentage of the female camel mating in the rutting season of the male camel is within the range as mentioned by the author.

The percentage of abortion was high in the pastoral traditional system, especially in the Butana region, which may be attributed to lack of veterinary care, more stress among the camels that move long distances to cover nutrition requirements by grazing and browsing mostly on acacia species or grazing on unidentified poisoning plants. The findings of the present study agree with the finding of Farah et al. (2004) who reported that the pastoral camel production is under pressure because of multiple changes in the pastoral environment, economic implications and traditional

factors of pastoral system. In current study, the lactation period is more than 9 months. Farah et al. (20 04) found that lactation period ranged between 9 to 18 months. Our findings do not match with that of the Tezera's (1998), who stated that the lactation period was 13-15 months for Ethiopian camels. On the other hand, finding of current study indicates longer period than that of the finding by Alemayehu (2001) who reported 6 to 8 months of lactation period. This variation might have emanated from ecotype, nutrition, management practices and differences in the production system.

The findings of this study regarding the high percentage of calving range during the productive age of female camel agrees with Farah et al.'s (2004) findings. According to them, under normal conditions, a female camel giving birth every other year will have 8 and 10 calves in her breeding life of around 25–30 years. Contrarily, these findings do not match with the findings of Raziq et al. (2008) where they reported that a she-camel produces up to 12 calves in her whole life span.

The amount of milk yield was found to be affected by many factors among different regions of camel production. These factors might include breeds, health conditions, type of pasture, stage, and season of lactation. The results revealed that the high percentage of yield in Butana and Kordofan is lower than the finding of Zeleke (2007) who observed that the mean daily milk yield of a camel in pastoral system was 3.75 liters. However, this fact is in line with Ali & Majid (2006) who reported that the amount of milk declines to 1.38 litre/day in Butana area, whereas it was found to be 2.36 litre/day under nomadic management system in Western Sudan. Furthermore, the stage of lactation of camels and parity significantly affected their daily milk yield in Ethiopia camel. Despite a high percentage of milk yield in the Darfur region, this study agrees with Bakheit (2008) who states that the average daily milk yield obtained from camel under the traditional system is 3.14 litre/day. Traditionally, there are cultural restrictions on the sale of camel milk, and it is not sold in the core camel production areas. Therefore, pastoralists were not interested in milk production to get cash.

The age of calving at weaning is slightly different between areas in this study. Overall weaning age is more than 10 months. This finding is in agreement with Abdelrahman et al. (2011), who reported that the dromedary calf was weaned between 12 and 16 months with a mean of 12.4 months in a traditional pastoral system in Nigeria. The result of this study disagreed with the finding of Farah et al. (2004). His findings suggest that the weaning of calves happen at the age of 8–18 months, depending on the browsing situation, milk production of the dam, growth of the calf, and ultimate use of the calf. Delay separation and weaning of calves have coincided with poor management in the traditional pastoral system, which possibly is the main reason for an increasing interval between calving. According to Khorchani et al. (2004), productivity could be improved by new techniques including early separation and artificial nursing of calves by reducing the interval between calving.

The traditional methods of calving and weaning are different across the regions in this survey. These variations can be attributed to the cultural diversity among the tribes of camel breeding. Some of the weaning methods in this study are also practiced in Somalia as mentioned in the study by Farah et al. (2004). They have described that several different systems of weaning are practiced by the Somali camel herders, of which the most prominent are: tying the dam's teats with a softened bark (maraq); making a small incision in the skin of the calf's nose-tip and inserting Acacia thorns that will prick the dam whenever the calf tries to suckle, and making a small incision at the top of the calf's tongue and inserting a piece of wood that will hurt the calf when it tries to suckle.

The majority of pastoralist in this study practiced suckling the calf few minutes before milking. It is a good process for milk letdown. This finding agreed with Farah

et al. (2004) and Eisa & Mustafa (2011), who reported that sucking process is adopted by camel herders in camel dairy production in Sudan. While milking frequency ranged from 1-3 times, most of the respondents emphasized on 2 times of milking per day in a pastoral system. This result was in accordance with the finding by Eisa & Mustafa (2011).

Most of the pastoralists considered the rainy season to be the main rutting season of male camel, and the length of rutting periods ranged from 2-3 months in this study. This finding is similar to Abdelrahman et al. (2011) who mentioned that the male camel exhibits rutting during the early-dry season between October and December coinciding with the cold period of the year. In this study, the calving interval is not less than 15 months; moreover, the majority of pastoralist respondents mentioned the parturition period ranging between 20 and 30 months. This finding agrees with the facts reported by Abdelrahman et al. (2011), that the mean calving interval was 23.8 months, and by Farah et al. (2004) who mentioned that the mean calving interval in the traditional pastoral system is 27.4 months.

The main signs of the estrus cycle, parturition, and pregnancy detection are carried out in this study; these are different among pastoral communities from one region to another. However, swelling of the vulva, swelling of the udder, and raise-up tail are common signs to identify the estrus cycle, parturition, and pregnancy in female camels respectively. This finding is in agreement with Abdelrahman et al. (2011), who recorded some prominent signs of estrus in the female camel including frequent urination, vulval discharge, vulval swelling, male seeking, bleating, foul vulval odour, tail raising, in appetence, grouping of camel cows, and cows mounting one another. According to Yagil (2006), a pregnant camel will show it by lifting and curving her tail (tail "cocking") when a male camel advances toward her. The male then moves away looking for another receptive female. This is the method used by nomads to determine pregnancy in she-camels.

The result reveals a high calve mortality rate ranging 1 to 5% in herds yearly. Death of calves before weaning is a critical problem in the traditional pastoral system. This finding is in agreement with Wilson (1986) who reported that in nomadic herds of dromedaries, the pregnancy losses are due to early embryonic death and abortions that vary from 3% to 33%.

Constraints in camel movement and nomadism

In this survey, many constraints were observed that limit the camel production in the study areas. First and foremost is the issue of the security in Kordofan and Darfur regions where internal conflicts between the farmers and pastoralists often lead into tribal wars. Such findings are in line with the data reported by Helen et al. (2009) where they found the camel-pastoralism to be under threat because of mounting insecurity inhibiting their movement patterns. Additionally, lack of desirable development efforts that could support the pastoralist lifestyles (for example, lack of water facilities on the routes), unfavorable and biased policies, pressures to settle down, and the economic incentives of maladaptive strategies make livestock rearing a less desirable and more challenging livelihood choice. At the same time, finding from the camel production system as observed in the Butana region is in agreement with the findings of Darosa (2005) where he reported the shortage of natural pasture and fodder in the region. According to him, expansion of mechanized agricultural activities is diminishing the availability of natural fodder making the herders highly dependent on crop residues. As a result of it, camel owners and herders have to bear a high price of purchasing crop residues from the farmers making the production system most competitive out of the three types discussed above.

5. Conclusion

Camel pastoral traditional system holds tremendous socio-economic potential because of its high productivity. However, that is only possible if this system is able to garner attention from the government authorities and organizations that could help them overcome the production related constraints. Based on the findings of this study, it can be concluded that the government needs to adopt appropriate policies that help in controlling the conflicts between pastoral tribes, securing their main routes of migration and spreading awareness regarding desirable camel management practices to boost the productivity of camel pastoral practices in the region.

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Author's Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*
Conceived and designed the research or analysis	Yes	Yes
Collected the data	Yes	No
Contributed to data analysis & interpretation	Yes	Yes
Wrote the article/paper	Yes	Yes
Critical revision of the article/paper	Yes	Yes
Editing of the article/paper	Yes	Yes
Supervision	Yes	No
Project Administration	Yes	No
Funding Acquisition	No	No
Overall Contribution Proportion (%)	75	25

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Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. Some contexts of animals are also indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work. Yet, we are appending the filled-in ARRIVE Checklist just for further clarifications.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has involved Indigenous Peoples as participants or respondents, with the documentation of their Indigenous Knowledge. Some other contexts of Indigenous Peoples or Indigenous Knowledge are indirectly covered through literature review. Therefore, a Self-Declaration in this regard is filed by the researcher and first author to support this study or written work.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment or field studies. The contexts of plants were only indirectly covered through literature review. Yet, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

(Optional) Research Involving Local Community Participants (Non-Indigenous)
The author(s) solemnly declare(s) that this research has involved local community participants or respondents belonging to non-Indigenous peoples. Yet, this study did not involve any child in any form directly or indirectly. The contexts of different humans, people, populations, men/women/children and ethnic people are also

indirectly covered through literature review. Therefore, because the consent of the Chairman of Pastoralists Union in Butana region was taken, a prior informed consent (PIC) of the individual respondents was not taken under this study before the face-to-face interviews and interactions.

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards. It is not relevant in case of this study or written work.

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Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

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The ARRIVE guidelines 2.0: author checklist

The ARRIVE Essential 10

These items are the basic minimum to include in a manuscript. Without this information, readers and reviewers cannot assess the reliability of the findings.

Item		Recommendation	Section/line number, or reason for not reporting
Study design	1	For each experiment, provide brief details of study design including: a. The groups being compared, including control groups. If no control group has been used, the rationale should be stated. b. The experimental unit (e.g. a single animal, litter, or cage of animals).	I didn't do laboratory experiments, only a field survey study.
Sample size	2	a. Specify the exact number of experimental units allocated to each group, and the total number in each experiment. Also indicate the total number of animals used. b. Explain how the sample size was decided. Provide details of any *a priori* sample size calculation, if done.	I didn't do laboratory experiments, only a field survey study.
Inclusion and exclusion criteria	3	a. Describe any criteria used for including and excluding animals (or experimental units) during the experiment, and data points during the analysis. Specify if these criteria were established *a priori.* If no criteria were set, state this explicitly. b. For each experimental group, report any animals, experimental units or data points not included in the analysis and explain why. If there were no exclusions, state so. c. For each analysis, report the exact value of *n* in each experimental group.	I didn't do laboratory experiments, only a field survey study.
Randomisation	4	a. State whether randomisation was used to allocate experimental units to control and treatment groups. If done, provide the method used to generate the randomisation sequence. b. Describe the strategy used to minimise potential confounders such as the order of treatments and measurements, or animal/cage location. If confounders were not controlled, state this explicitly.	I didn't do laboratory experiments, only a field survey study.
Blinding	5	Describe who was aware of the group allocation at the different stages of the experiment (during the allocation, the conduct of the experiment, the outcome assessment, and the data analysis).	I didn't do laboratory experiments, only a field survey study.
Outcome measures	6	a. Clearly define all outcome measures assessed (e.g. cell death, molecular markers, or behavioural changes). b. For hypothesis-testing studies, specify the primary outcome measure, i.e. the outcome measure that was used to determine the sample size.	Nothing
Statistical methods	7	a. Provide details of the statistical methods used for each analysis, including software used. b. Describe any methods used to assess whether the data met the assumptions of the statistical approach, and what was done if the assumptions were not met.	MS Excel 16 to calculate percent and frequency. We just computed the percent and frequency in our survey.
Experimental animals	8	a. Provide species-appropriate details of the animals used, including species, strain and substrain, sex, age or developmental stage, and, if relevant, weight. b. Provide further relevant information on the provenance of animals, health/immune status, genetic modification status, genotype, and any previous procedures.	I didn't do laboratory experiments, only a field survey study.
Experimental procedures	9	For each experimental group, including controls, describe the procedures in enough detail to allow others to replicate them, including: a. What was done, how it was done and what was used. b. When and how often. c. Where (including detail of any acclimatisation periods). d. Why (provide rationale for procedures).	I didn't do laboratory experiments, only a field survey study.
Results	10	For each experiment conducted, including independent replications, report: a. Summary/descriptive statistics for each experimental group, with a measure of variability where applicable (e.g. mean and SD, or median and range). b. If applicable, the effect size with a confidence interval.	Descriptive statistic with percent and frequency of data.

SELF-DECLARATION FORM
Research on Indigenous Peoples and/or Traditional Knowledge

The nature and extent of community engagement should be determined jointly by the researcher and the relevant community or collective, taking into account the characteristics and protocols of the community and the nature of the research.

If your research involved/involves the Indigenous Peoples as participants or respondents, you should fill in and upload this Self-Declaration and/or Prior Informed Consent (PIC) from the Indigenous Peoples. [Please read carefully https://grassrootsjournals.org/credibility-compliance.php#Research-Ethics]

1. Conditions of the Research

1.1 Was or will the research (be) conducted on (an) Indigenous land, including reserve, settlement, and land governed under a self-government rule/agreement or?

Yes

1.2 Did/does any of the criteria for participation include membership in an Indigenous community, group of communities, or organization, including urban Indigenous populations?

Yes.
What kind of membership?
Groups of communities

1.3 Did/does the research seek inputs from participants (members of the Indigenous community) regarding a community's cultural heritage, artifacts, traditional knowledge, biocultural or biological resources or unique characteristics/practices?

Yes

1.4 Did/will Aboriginal identity or membership in an Indigenous community used or be used as a variable for the purposes of analysis?

Yes

2. Community Engagement

2.1 If you answered "Yes" to questions 1.1, 1.2, 1.3 or 1.4, have you initiated or do you intend to initiate an engagement process with the Indigenous collective, community or communities for this study?

Yes

2.2 If you answered "Yes" to question 2.1, describe the process that you have followed or will follow with respect to community engagement. Include any documentation of consultations (*i.e., formal research agreement, letter of approval, PIC, email communications, etc*.) and the role or position of those consulted, including their names if appropriate:

Researcher consulted the chairman of pastoralists union in Butana region. Researcher took some pictures with pastoralists and their animals in free range, and those pictures are included in the text of the article.

3. No Community Consultation or Engagement

If you answered "No" to question 2.1, briefly describe why community engagement will not be sought and how you can conduct a study that respects Aboriginal/ Indigenous communities and participants in the absence of community engagement.

Not Applicable.

Name of Principal Researcher: Ayman Balla Mustafa (PhD)
Affiliation of Principal Researcher: Associate Professor, Therapeutic Nutrition Department, Faculty of Health Sciences, Misurata University, P. O. Box: 2478, Misurata, Libya

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